The National Aging Aircraft Research Program

As a result of accidents at the end of the last decade, Congress passed the Aviation Safety Research Act of 1988 (Public Law 100-591) and increased the scope of the Federal Aviation Administration (FAA) mission to include research on methods for improving maintenance technology and detecting the onset of cracking, delamination, and corrosion of aircraft structures.

In response, the FAA developed the National Aging Aircraft Research Program (NAARP). As a result of concerns relating to the increasing age of the air carrier fleet, the FAA is conducting research to ensure the continued airworthiness of high-time, high-cycle aircraft. The research in the NAARP includes the areas of structural integrity, corrosion, inspection systems, aircraft engines, airborne data monitoring systems, maintenance and repair and rotorcraft structural integrity.

Structural Integrity Research

The research activities in this program area include both the large and small transport. Of primary concern is the effect of simultaneous cracks at multiple structural details on structural integrity of aircraft structures. Predictive methodologies to analyze structural designs in terms of their damage tolerance capabilities and fatigue lives are under development. Tests are ongoing to validate the analytical methods under development. *The photograph on the right shows the pressurized curved panel test fixture that will be operated at the Technical Center.* Damage tolerance principles, commonly used for large transport aircraft, are being extended to commuter aircraft. For further information, contact Paul Tan, (609) 485-6665, or Richard Micklos, (609) 485-6531.

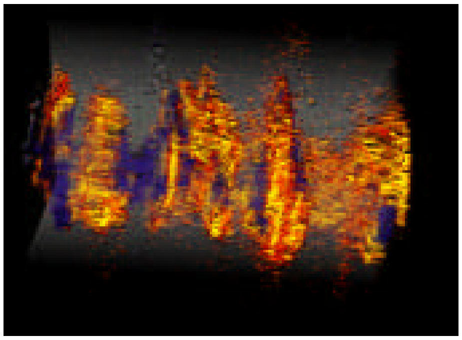
Corrosion Research

This research is focused in two areas: investigation of corrosion-fatigue interaction and development of corrosion control procedures. The research will lead to the development of a more realistic structural integrity evaluation of fuselage lap joints, and other aircraft design details, which includes the effects of corrosion. For further information, contact Thomas Flournoy, (609) 485-5327.

Inspection Systems Research

The research is this program area is focused on developing new methods and techniques to detect cracks, corrosion, and disbonding. A large part of the basic research is done at the Center for Aviation Systems Research (CASR), which is composed of Iowa State University, Northwestern University, Wayne State University, and Tuskegee University. The FAA Aging Aircraft Nondestructive Validation Center (AANC) at Sandia National Laboratory then conducts validation and final development of inspection procedures. Aging aircraft and other specimens in the FAA Sample Defect Library housed at AANC are used to conduct the validation tests. For further information, contact Chris Smith, (609) 485-5221.

Aircraft Engine Research
Research in this program area is focused in two areas. The first will develop a crack growth-based predictive methodology for engine static components and use that methodology to derive maintenance and inspection management program for commercial pressurized engine cases that may rupture due to fatigue cracks, initial flaws, and weld repairs. The second is developing improvements in titanium billet inspection practices and technology, analysis and enhancement of inspection reliability, and improvements to in-service inspections for engine components. *A computer visualization of titanium defect is shown on the left.* This research is being done by the Engine Titanium Consortium, which is made up of Iowa State University, General Electric, Pratt & Whitney, and AlliedSignal Engines. For further information, contact Richard Micklos, (609) 485-6531.



Airborne Data Monitoring Systems Research
A video landing data acquisition system has been developed to collect data on typical landing impact conditions for both large and small transport aircraft, and a series of surveys are underway at commercial airports. In addition, flight load data are being collected for large and small transport aircraft. For further information, contact Thomas DeFiore, (609) 485-5009.

Maintenance and Repair Research
Improved maintenance and repair technologies are being identified and maintenance and repair practices from effective programs are being incorporated into appropriate user documentation. The results from this research will provide input for the Advisory Circular (AC) 43.13 series and other AC series. The input will include current and new information on airframe metal repairs, maintenance, and inspection. For further information, contact James Newcomb, (609) 485-5720.

Rotorcraft Structural Integrity
The research in this area is focused on two activities. The first will provide input for an Advisory Circular on health and usage monitoring system certification criteria. The second will address the use of damage tolerance methods to establish inspection intervals for existing and new rotorcraft designs. For further information, contact William Emmerling, (609) 485-4009.

To find out more about the National Aging Aircraft Research Program, contact:

Airport and Aircraft Safety Research and Development Division
Airworthiness Assurance Research and Development Branch
Maintenance, Inspection, and Repair Section, AAR-433
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Aging Aircraft Structural Integrity Research

In response to public concerns after the Aloha Accident, Congress passed legislation known as the Aviation Safety Research Act of 1988. As a result of the Act and concerns relating to the increasing age of the air carrier fleet, the FAA developed the National Aging Aircraft Research Program (NAARP) to ensure the structural integrity of high-time, high-cycle aircraft. The NAARP structural integrity program area includes three major elements: Methodologies to predict the onset of widespread fatigue damage (crack initiation, crack growth, and residual strength), supplemental structural inspections for commuter aircraft, and airframe repair assessment.

Methodologies to Predict the Onset of Widespread Fatigue Damage: Widespread fatigue damage (WFD) in a structure is characterized by the simultaneous presence of cracks at multiple structural components where the cracks are of sufficient size and density that the structure will no longer meet its damage tolerance requirement. To ensure that the residual strength of an aging aircraft is not degraded below limit levels due to the occurrence of WFD, predictive methodologies to identify the onset of WFD during the operational life of an airplane have been developed. The methodologies are currently being verified by test data from coupon tests, sub-scale component tests, full-scale tests, and service experience. *The photograph above shows an experimental test fixture that has been designed to test full-scale curved, stiffened panels under pressure and biaxial loading which will be used to validate the predictive methodologies.* The test fixture is located at the FAA William J. Hughes Technical Center, Atlantic City International Airport; New Jersey.

A computational tool is also under development to quantify the risks associated with the uncertainties inherent in the occurrence of WFD. The risk model combines probabilistic techniques and structural analysis capabilities and will be used to do sensitivity studies, aircraft certification, and evaluations of inspection and maintenance strategies.

Supplemental Structural Inspections for Commuter Aircraft: Increased utilization, longer operational lives, and the high safety demands imposed on currently operating air carrier airplanes have indicated that there is a need for a program to provide for a high level of structural integrity for all airplanes in the commuter transport fleet. Supplemental Inspection Programs (SIP) have been used successfully to provide this level of safety in the large transport segment of the industry.
To extend this concept to commuter category airplanes, the FAA proposes changes to require all airplanes operated under CFR Part 121, all U.S.-registered multiengine airplanes operated under

part 129, and all multiengine airplanes used in scheduled operations conducted under part 135 to undergo inspections after their 14th year in service to ensure their structural integrity. The proposed rule would also require that damage tolerance (DT) -based SIPs be developed for these airplanes before specific deadlines. This proposal represents a critical step toward compliance with the Aging Aircraft Safety Act of 1991. It ensures the continuing airworthiness of aging airplanes by applying modern DT analysis and inspection techniques to older airplane structures that were certificated before such techniques were available.

Many commuter airplane manufacturers and operators do not have the large engineering staffs, budgets, or fleet sizes to support a program as extensive as the large transport program. To ease this burden, the FAA is assisting U.S. manufacturers of selected airplane models to develop Supplemental Inspection Documents (SIDs) which could then be used by operators to develop SIPs.

Airframe Repair Assessments: *A critical issue identified by the aviation industry (civilian and military) is the need to examine the effects of repairs on the structural integrity of aircraft.* The use of damage tolerance methodologies in the maintenance and repair practices of aircraft is required in order to insure their continued airworthiness and operational safety. The resources needed for damage tolerance designs of repairs are lacking for small operators, independent repair facilities, and military repair depots. In an effort to address this need, a task was undertaken under the joint sponsorship of the United States Air Force (USAF) and the Federal Aviation Administration (FAA) to develop a new, user-friendly software tool, Repair Assessment Procedure and Integrated Design (RAPID), capable of static strength and damage tolerance analyses of fuselage skin repairs. Version 2.0 of RAPID, which can analyze repairs on an aircraft fuselage, has been released; future work will focus on commuter category aircraft.

To find out more about the Aging Aircraft Structural Integrity Program, contact:

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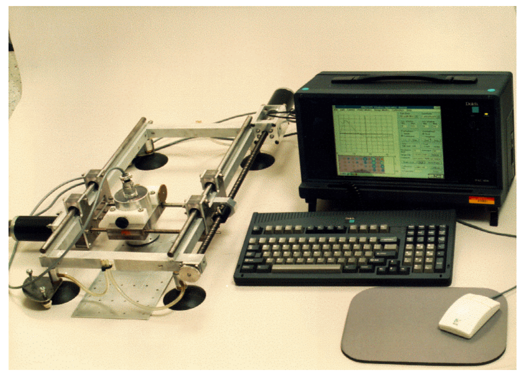
Aging Aircraft Inspection Systems Research

The Aviation Safety Research Act of 1988 directed the FAA to develop technologies and conduct data analyses for predicting the effects of aircraft design, testing, wear, and fatigue on the life of aircraft and on air safety. It also expanded the research mission of the FAA to include research to improve maintenance technology and the detection of cracking, delamination, and corrosion of aircraft structures. Pursuant to this Act, the FAA developed the National Aging Aircraft Research Program of which the Inspection Systems Research is a major program area.

The inspection systems research program is divided into two parts: Inspection Systems Development and Inspection Systems Validation. Within the Inspection Systems Development program area, tasks have been grouped into five categories.



Crack Detection: This research is directed at improving the sensitivity and reliability of techniques to detect and characterize small, inter-layer, and obscured cracks characteristic of widespread fatigue damage and improving the sensitivity of techniques to detect small cracks in engine components. Technologies of current general interest include: laser ultrasonics, *pulsed eddy current (shown in the photograph)*, superconducting quantum interference devices (SQUIDs), ultrasonic pulse compression, energy sensitive x-ray for engine case inspection, dual probe ultrasonics, electromagnetic acoustic transducers, advanced electromagnetic sensors for widespread fatigue damage assessment, and an advanced penetrant inspection technology. Tasks focused on engine rotating components include: a portable eddy-current instrument and scanner, specifications for a shop eddy-current scanner, a data acquisition and analysis system, a low-pressure rotor rotator, a study of the applicability of eddy-current arrays to engine disk inspection, 2D and 3D image display and signal and image processing algorithms, and an optimal eddy-current probe for typical engine disk inspections.

Bond Integrity Verification: This research is developing noninvasive techniques to detect and characterize disbonding and understrength bonds in skin splices and developing noninvasive techniques to detect and characterize flaws in composite structure. Technologies of current interest include: thermography (thermal wave imaging), low-frequency ultrasonic scanning, air-coupled ultrasonics, and capacitive array sensors (for inspection of composites).

Corrosion Detection: This research is focused on developing noninvasive techniques to detect and characterize corrosion in skin splices and other airframe structures. Technologies of current interest include: magneto-optic eddy current imaging (MOI); pulsed eddy current; optical enhancement of surface contour (D-Sight); and portable, low-radiation hazard, real-time x-ray.

Robotics and Automation: The capability and reliability of inspection systems will be enhanced by developing faster more accurate means of deploying the probes and interpreting probe signals. Technologies of current interest include: signal processing for sliding and rotating eddy-current probes, self-focusing ultrasonics, and signal processing for ultrasonic billet inspection.

Process Control and Quality Assurance: Inspection methodologies are being developed for engine and airframe components which, when applied in the manufacturing environment, can reduce the occurrence of latent defects capable of causing severe in-service failure. This task area is presently focused on multizone and focused array ultrasonics for billet inspection.

Accurate assessments of the reliability of inspection techniques are critical to the effectiveness of any continued airworthiness program. The Inspection Reliability and Validation initiative encompasses several approaches including experimental analysis, maintenance data analysis, and simulation to assess the reliability of inspection techniques. The six specific tasks under in this task area are:

Reliability Assessment Tool: Methods, algorithms, and hardware are being developed to assess the reliability of conventional and emerging inspection equipment, materials, and systems.

Visual Inspection: This task area will quantify the reliability associated with the visual inspection of aircraft, identify areas where visual processes can be improved, and identify methods for enhancing the reliability of the visual inspection process.

Task Structured Experiments: Experiments are designed to provide FAA Certification and Flight Standards Offices with independent, quantitative evaluations of current practices and to assess and compare emerging nondestructive inspection technologies and procedures for application to specific aircraft structures.

Liquid Penetrant Evaluation: A capability will be established at the FAA AANC to maintain a working penetrant qualification process following USAF guidelines to assist industry in the evaluation of penetrant inspection materials, products, systems, and technology.

Composite Reference Standards: A set of composite calibration standards will be developed to be used for nondestructive testing equipment calibration during damage assessment and post-repair inspection of commercial aircraft composites.

Technology Transfer: To expedite industry's acceptance of the new and emerging inspection technologies developed by the FAA's Inspection Research Program. Technologies selected for transfer are those which will improve safety and, where possible, reduce inspection costs.

To find out more about the Aging Aircraft Inspection Systems Program, contact:

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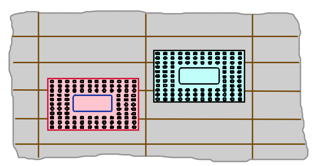
Repair Assessment Procedure and Integrated Design (RAPID)

A critical issue identified by the aviation industry (civilian and military) is the need to examine the effects of repairs on the structural integrity of aircraft. The incorporation of damage tolerance methodologies in the maintenance and repair practices of aircraft is required in order to insure their continued airworthiness and operational safety. The resources needed for damage tolerance designs of repairs are lacking for small operators, independent repair facilities, and military repair depots. In an effort to address this need, a task was undertaken under the joint sponsorship of the United States Air Force (USAF) and the Federal Aviation Administration (FAA) to develop a new, user-friendly software tool, Repair Assessment Procedure and Integrated Design (RAPID), capable of static strength and damage tolerance analyses of fuselage skin repairs.

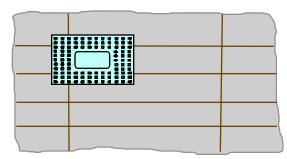
RAPID is a simple, PC-based repair tool with a modularized open system architecture to provide easy implementation of upgrades and new features. In the development of this tool, emphasis has been placed on using generic engineering approaches for use in a Windows-based, user-friendly software tool that can run on a PC computer with minimal hardware and software requirements. The targeted audience for RAPID are people in the aircraft repair industry in need of analysis tools to conduct damage tolerance analysis of repairs such as third party repair facilities, independent designated engineering representatives (DERs), FAA aircraft certification offices (ACOs), and USAF repair depots.

The fuselage skin repairs considered in RAPID consist of a rectangular skin cut-out of the damaged area and doublers mechanically fastened to the skin. Complex fuselage skin repairs found in actual operating conditions can be assessed using RAPID, *including repairs near other repairs, repairs of splice joints, and repairs over stiffeners, as shown below*. RAPID assesses fuselage skin repairs for static strength and damage tolerance requirements.

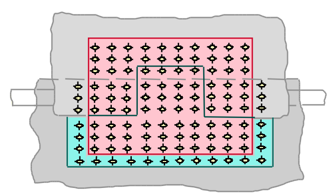
The static strength analysis is based on the margin of safety calculated using the allowables of the doublers and the fastener joints. The methodology includes shear and compression analysis capabilities of the repairs. Inter-rivet buckling between adjacent fasteners and the panel buckling of the repair doubler are examined against the compression strength allowables of the materials.



Repairs Near Other Repairs



Repairs Over Stiffeners

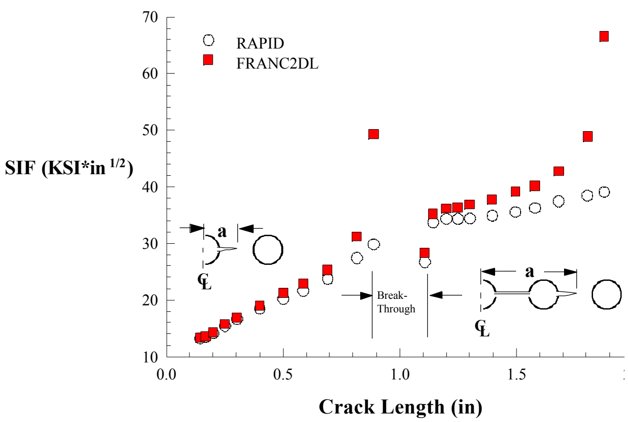


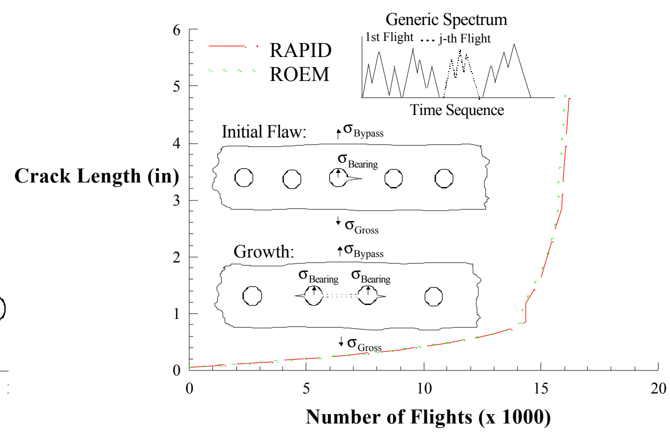
Repairs Over Joints

The damage tolerance analysis (DTA) in RAPID is based on a procedure which involves several steps including the calculation of fastener loads, assumption of the initial flaw geometry and growth, and calculations of stress-intensity factors, crack growth, residual strength, and inspection schedule. The DTA is conducted at the center and corner fastener holes in the skin on each side of the repair. The center fastener is analyzed since inspections at that location can be difficult; the corner fastener is analyzed since it is typically the highest loaded fastener. The two analyses are conducted on all sides since there may be an asymmetric condition due to substructure or adjacent repairs.

Two crack growth models are available: a simplified approach based on Walker's equation and a cycle-by-cycle approach. The load spectra database includes a generic narrow-body and wide-body load spectra. The corresponding stress spectra are determined based on the location of the repair on the aircraft. An equivalent stress cycle spectrum can be derived from any stress spectrum history and can be used in the simplified crack growth analysis. In addition, a user-defined stress spectrum can be input to RAPID to be used in an analysis.

The analysis methodology in RAPID has been validated using in-house and commercial finite element programs. *In the figures below, RAPID generated results for the stress-intensity factor (SIF) solutions and the crack growth analysis.*





In general, there is good agreement in the SIF calculations made using RAPID and FRANC2DL (a two-dimensional finite element analysis) for the initial crack growth. As the crack tip approached a boundary, i.e., a rivet hole or specimen edge, there is a noticeable difference between the two analyses; however, this occurs over a very short crack extension length. After the first breakthrough condition, the difference increases as the crack length increases. The finite width of the finite element model contributes to this increasing difference. To validate the crack growth calculations, the crack growth was determined for a generic spectrum using the cycle-by-cycle crack growth model in RAPID and compared with a representative original equipment manufacturer (ROEM) approach. In general, the results are in good agreement.

To find out more about the RAPID Program, contact:

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FAA Engine Titanium Consortium

The FAA established the Engine Titanium Consortium (ETC) in 1993 to respond to recommendations made by the FAA Titanium Rotating Components Review Team (TRCRT) for improvements in inspection of engine rotating components. The ETC was established with the objective of providing the FAA and engine manufacturers with reliable and cost-effective new methods and/or improvements in mature methods for detecting cracks, inclusions, and imperfections in titanium material and components. The ETC consists of a team of researchers from academia and industry -- Iowa State University, Allied Signal Propulsion Engines-Garrett, General Electric Aircraft Engines, and Pratt & Whitney. Major advancements are being made in the industry's ability to inspect critical rotating components both in production and in-service.

The ETC program was formulated with two distinct phases. In Phase I the ETC addressed the high-priority specific recommendations of the 1990 TRCRT report. Phase I, completed in 1998, was a four-year effort focused on developing an understanding of the fundamental material properties of titanium and hard alpha, including their response properties to ultrasonic interrogation, developing billet inspection technology, developing tools for the detection of fatigue cracks typical of those that might emanate from hard alpha inclusions, and developing and applying tools to assess the reliability of inspection of rare defects. *Shown on the right is a portable scanner that has been developed for use in airline overhaul and maintenance shops.* The portable scanner consists of a generic mechanical scanning system with application specific tooling for probe positioning and manipulation. Adapter plates are used to mate the mechanical scanning system to a variety of engine disks by using the bolt hole patterns to align the system to specific disks.

Major ramifications of the Phase I effort are already evident in aviation community.

> An enhanced ultrasonic technique has been developed and implemented to detect defects in the titanium billet material used to manufacture engine rotating components. The system has demonstrated a four-fold improvement in defect detection compared to the current inspection and recently detected a defect that was missed by the conventional inspection system. To date, three billet production locations have inspected over 5.5 million pounds of titanium billet using this advanced technique. The new inspection technique will decrease the possibility of engine failure due to undetected flaws and increase the reliability and efficiency of inspection procedures for engine critical components. An industry-wide ultrasonic billet inspection specification based on the new technique has been developed and has been approved by the Society of Automotive Engineers (SAE) Committee K and the SAE Aerospace Council.

> In July 1996, Hamilton Standard presented a new blade shank repair to representatives of the FAA. This new repair was made possible by eddy current inspection technology developed by the ETC and expanded the dent repair limits while maintaining the design structural integrity of the blade. The new repair permitted the return to service of approximately 200 blades, which helped the operators meet the shank inspection deadline without grounding any aircraft. The FAA estimated that the cost of grounding the affected aircraft had the repair not been done properly and in a timely fashion was $15 million.

Phase II of the ETC Program will focus on leveraging the technologies and tools developed in Phase I for application to other critical materials and applications. Principally this involves development of nickel billet and titanium forging inspection systems, the further advancement of in-service inspection tools to address emerging needs, and the extension of reliability assessment methodologies to other applications including in-service eddy-current inspections.

Throughout Phase II, scheduled to begin in late 1998, the ETC will continue to coordinate and cooperate with organizations pursuing related efforts. These organizations include the Rotor Integrity Subcommittee (RISC), Jet Engine Titanium Quality Committee (JETQC), the Special Metals Processing Consortium (SMPC), and the Air Transport Association's Nondestructive Testing (ATA NDT) Network.

To find out more about the FAA Engine Titanium Consortium, contact:

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Aging Aircraft Airborne Data Monitoring Systems

Many of today's large and small commercial transports are being flown beyond their original intended service lifetimes, and the only feedback the FAA and the airframe manufacturers get from current US. air carrier operators is the number of flight hours and landings. This information defines the pressurization cycles and, thus, the major loads on the pressure hull. The loading history of the rest of the aircraft, wing, tail, flaps, controls, etc., which is dependent on flight operations, is assumed or estimated by approximate methods that are rarely substantiated by actual measurements. In addition, de-regulation, advances in technology, and the increased demand for and quantity of air travel have significantly modified how commercial aircraft are being flown.

Because this current practice of flying commercial transports near or beyond their original intended service lifetimes is a trend which is likely to continue into the foreseeable future, an need exists to acquire usage information describing the loading history of the entire aircraft. In addition, without large amounts of new service history usage data, the design criteria for future generations of aircraft cannot be reliably determined.

The Code of Federal Regulations, Aeronautics and Space, Airworthiness Standards are replete with loads criteria much of which were generated prior to deregulation and in some cases prior to the design of both wide body and fly-by-wire civil aircraft. With the existence this new technology, and newer operating rules and practices, and the anticipation of double the air traffic within ten years, a need exists to collect large amount of in-service loads data to characterize current usage of both large and small civil aircraft.

The Flight and Grounds Loads Program Area has two major elements in the program: the measurement and analysis of flight loads, and the measurement and analysis of ground or landing loads. The activities under way in flight loads includes acquiring and publishing data from the limited number of prior loads data collection surveys, as well as installing flight load recorders on selected large and small civil transports to determine flight profiles and in-service load usage information.

The civil transport aircraft flight loads data collection program has been re-establishment for both large and small transport aircraft. Some recent accomplishments include:

- Purchase and installation of a prototype optical disk ground station.
- Completed technical report summarizing 900 hours from USAir B-737 aircraft.
- Purchase of twelve Optical Quick Access Recorders for installation in USAir B-737/400 and Alaska Airlines MD-82 aircraft; over 25,000 hours of new data have been collected to date.
- Purchase of a Flight Data Replay and Analysis Ground Station for each airline.
- Development and purchase of six solid state recorders for commuter flight loads survey.
- Installation of a light-weight, low-cost small airplane flight loads monitoring recorder.

In addition, the FAA Technical Center will also establish state-of-the-art flight loads data collection and structural loads monitoring systems to provide large quantities of typical in-service usage history data to support the regional/commuter structural life assessment and extension programs. This research consists of the following tasks: (1) installation of 12 solid state recording systems in the regional/commuter airline fleet; (2) development of a light-weight, low-cost flight loads data recording system for small aircraft, which can be used to provide in-flight service usage history from which manufacturers and operators can formulate more reliable inspection programs; and, (3) software to calculate FAR 23 structural design and fatigue loads from an airplane's basic geometric, aerodynamic, and mass data.

The FAA is conducting a series of video landing parameter surveys at high-capacity commercial airports to acquire a better understanding of typical contact conditions for a wide variety of aircraft and airports as they relate to current aircraft design criteria and practices. As the first step in this research, the FAA, teamed with the US Navy, developed and tested a four-camera video landing parameter survey system designed to record aircraft landing in operational conditions. The system is designed to be installed at an airport without interfering with the airport's normal operation. To date four such surveys have been completed at John F. Kennedy International Airport, Washington National Airport, Honolulu International Airport, and London City Airport in the United Kingdom. *The photograph shows one of the four video camera recording an aircraft as it touches down.* Video landing loads surveys are planned each year for the next five years. Presently, a video landing loads facility is being established at the Atlantic City International Airport to collect landing usage data which will characterize both fair and poor weather operations.

Other loads research is being conducted in support of the FAA National Resource Specialist (NRS) on Flight Loads and Aeroelasticity. Some of this includes developing Statistical Discrete Gust Loads Criteria, developing a definition of the operational conditions prone to asymmetric buffet loads, deriving the proper sampling rate for controls parameters on the Digital Flight Data Recorder, and other research as proposed by the FAA NRS.

To find out more about the Aging Aircraft Flight and Ground Loads Program, contact:

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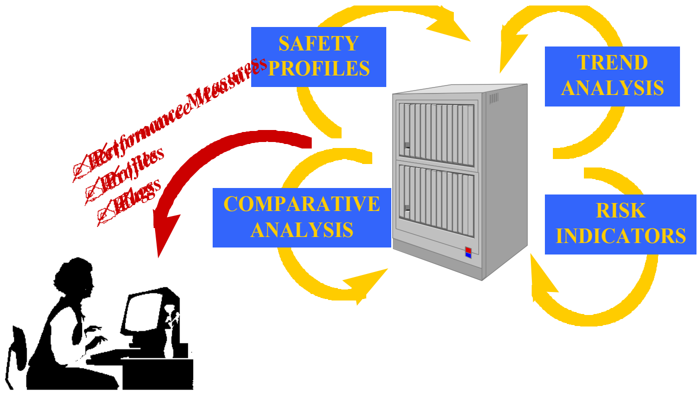
Aviation Safety Risk Analysis Program

The Federal Aviation Act of 1958 and the Code of Federal Regulations (CFR) provide the FAA with the statutory authority and responsibility to conduct surveillance of air operators, air agencies, aircraft, and airmen to assure conformance with the CFR and aviation safety standards. The Aviation Safety Risk Analysis Program (ASRAP) is developing analytical and decision support tools to provide FAA aviation safety inspectors and certification engineers the capability to systematically assess potential risks and take proactive steps to reduce the rate of aviation-related accidents and incidents. By targeting its resources based on risk, the FAA will be able to increase its leverage of aviation safety inspector and certification engineering resources.

ASRAP focuses on:



- Developing rapid prototyping techniques and software tools for use in generating new safety critical performance measures, displaying information, and facilitating analysis. These measures, encompassing particulars about aircraft design, aircraft maintenance, discrepancy reports, air carriers, air agencies, and air personnel, are to be embedded in decision support systems such as the Safety Performance Analysis System (SPAS).

- Investigating the use of artificial intelligence techniques, such as neural networks and experts systems, coupled with advanced statistical techniques to improve aviation safety analysis.

- Developing and enhancing safety assessment methods for certification and continued airworthiness of civil aircraft.

- Developing advanced analytical and graphical techniques that will allow the FAA to more effectively and efficiently use information contained in various FAA and industry databases.

- Improving the aviation safety monitoring and oversight process through the identification and testing of FAA and industry major attributes (i.e., characteristics) of safety and the relevant data that are required.

- Developing techniques to improve the quality of aviation safety data, collection procedures, and terminology.

Maximizing the sharing of good quality information would alert both the FAA and industry of pending aviation safety-related problems. Analytical and decision support tools rely on good quality data to identify the potential safety risk areas. By developing a certification and surveillance program that is built on targeting resources to address safety risks, corrective action would be taken sooner. Thus, the primary beneficiaries of this effort is the general flying public.

Several of the analytical tools; e.g., SPAS, will also be used by the Department of Defense (DoD) in their oversight of DoD contract carriers and charters.. The FAA is working with Helicopter Association International to enhance their Maintenance Malfunction Information Reporting (MMIR) System. This software tool improved the collection, storage, and transfer of service difficulty reports and part warranty information. It is a goal of the ASRAP program to expand the use of MMIR to other type operators, e.g., air taxis.

The work is carried out by FAA staff, contractors, and academia. The work, from determining system requirements to developing interface standards for constituent systems, is performed in conjunction with Flight Standards and Aircraft Certification users and industry working group subject matter experts ensuring that the initiative will fulfill user needs. Additional expertise is provided by the US Air Force, the Department of Transportation (DOT), the Department of Energy (DOE) through interagency agreements. Support from the Flight Safety Foundation and academia is sought through the use of cooperative grants and agreements.

Joint Application Requirement/Joint Application Design (JAR/JAD) is the process used to more fully define the user requirements and the ultimate screen displays. During the JAR and JAD sessions, developers work with the subject matter experts. Mockups and rapid prototypes are the primary display mechanisms used to ensure that the developers have a comprehensive understanding of the requirements. For major system development efforts, an independent verification and validation of the initiative is conducted to ensure that the requirements are met.

Released in 1997, SPAS II is a computer-based risk analysis decision support system to be used by FAA aviation safety inspectors and certification engineers, as well as DoD aviation analysts. SPAS II includes safety critical performance indicators, as well as aviation safety information so that its users can monitor the performance of certificate holders; i.e., air operators, air agencies, aircraft, and air personnel. When fully deployed to all sites (by 1999), SPAS II will extend into foreign cities, such as Singapore, as well as throughout the US.

Released in 1997, the International Aircraft Operators Information System (IAOIS) is a computerized information system which, at the present time, contains detailed information on more than 110,000 fixed-wing aircraft and helicopters as well as information on more than 70,000 aircraft operators worldwide. The IAOIS project was initiated to improve the US Aircraft Registry Information System with higher data quality, state-of-the-art relational database technology, more detailed information on aircraft and operators, and an international scope.

To find out more about the Aviation Safety Risk Analysis Program, contact:

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Aircraft Catastrophic Failure Prevention Program

The FAA forecasts that U.S. carriers alone will carry 1.2 billion passengers by the year 2015. This will occur with a 40 percent increase in the number of flights. If the current accident rate remains unchanged, some experts predict accidents resulting in numerous fatalities and an aircraft hull loss occurring as frequently as every 7 to 10 days. This potential is the primary driver behind the need to reduce the accident rate toward the zero accident goal. The Aircraft Catastrophic Failure Prevention Program is working to make sure this prediction does not become reality.

The Aircraft Catastrophic Failure Prevention Program was created by Congress in 1990 (Public Law 101-508) with the intended goal of improving aircraft system safety by developing technologies and methods that will assess the risk and prevent defects, failures, and malfunctions of aircraft, aircraft components, and aircraft systems which could result in catastrophic failure of aircraft. The Aircraft Catastrophic Failure Prevention Program focuses principally on mitigating the hazard associated with propulsion, flight control, and structural failures that occur during operation. Priorities for research are set by using historical accident data and National Transportation Safety Board (NTSB) recommendations to identify areas for research:

- Turbine engine uncontainment events including mitigation and modeling of uncontainment and the aircraft vulnerability to uncontainment. This research area was identified as the top priority by the Aerospace Industries Association Continued Airworthiness Assessment Methodologies report and is responsive to NTSB recommendations A-72-006, A-82-38, A-84-060, A-90-170, A-90-169.

- Developing alternate means of controlling an aircraft when the primary flight control system is damaged or degraded. This research area addresses the DC-10 crash at Sioux City and the JAL crash where flight controls were damaged as a secondary result of a component failure. This research is responsive to NTSB recommendation A-90-169.

- Examining the issues associated with inappropriate crew response to propulsion malfunctions and working with industry to develop solutions to this critical problem. This research area was identified as the second priority by the Aerospace Industries Association Continued Airworthiness Assessment Methodologies report and is responsive to NTSB recommendations A-79-105, A-87-009, and A-95-098.

FAA engineers are working with industry to update Advisory Circular (AC) 20-128 "Design Precautions for Minimizing Hazards to Aircraft From Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failures" and to develop a calibrated design system which will be used to minimize hazardous effects of turbine engine (including auxiliary power unit) rotor failures on a transport aircraft. This effort, involving specialists from the FAA, military, industry, and national laboratories is targeted for completion in the year 2000.

Working in conjunction with NASA, the FAA will develop an integrated system, demonstrated by flight tests and simulator tests, consisting of a self-repairing flight control system and propulsion controlled aircraft technologies that will allow continued safe flight and landing of a transport aircraft with damage, failures, or malfunctions which can be more extensive than envisioned by the current regulations. Certification guidelines and regulatory material will also be provided.

Again, working with industry and the Aerospace Industries Association Transport Committee on Propulsion System Malfunction Plus Inappropriate Crew Response, the FAA will develop improved training methods and an engine failure warning system that will be used to decrease the incidence of inappropriate crew response to propulsion related problems. Additionally, a technical report will form the basis for new regulations for an engine failure warning system as well as advisory circular material.

Future work also includes the development of appropriate modeling techniques and necessary guidance material to develop Advisory Circular (AC20-XX) to predict the effects on aircraft structure, system, and flight crew from an imbalanced engine caused by loss of a fan blade or blades or a bearing failure.

The Aircraft Catastrophic Failure Prevention Program will introduce technologies and design procedures that will reduce the number of catastrophic accidents. By using enhanced computational capabilities and vulnerability analysis techniques, it will provide technologies and certification criteria to increase the survivability of transport aircraft with extensive failures, malfunctions, or damage.

To find out more about the Aircraft Catastrophic Failure Prevention Program, contact:

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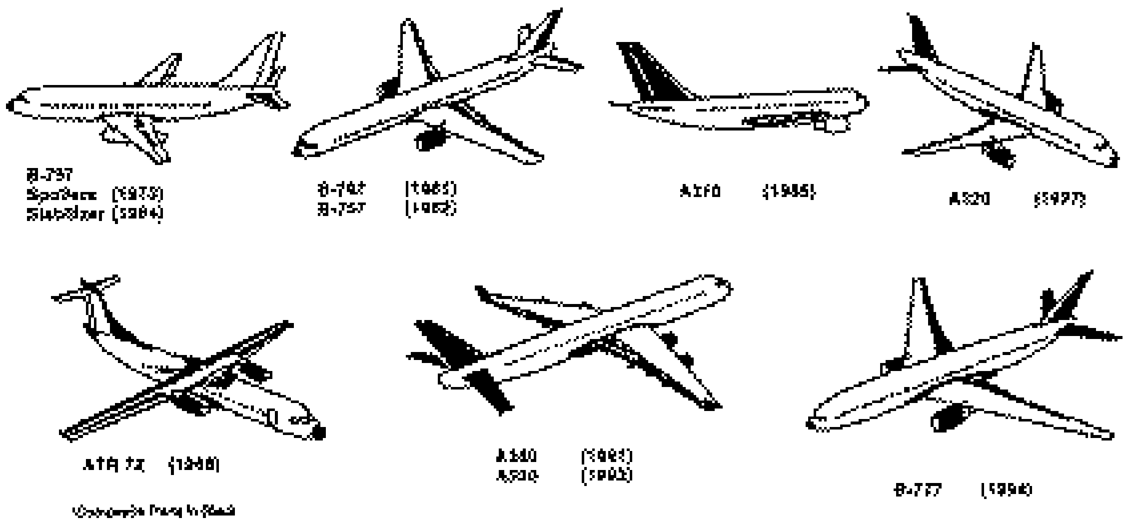
Advanced Materials Research Program

The application of polymeric composite materials to aerospace structures over the past 30 years is well documented. The higher specific strength and stiffness of reinforced composites versus metals, as well as other attributes such as tailorability to load directionality, acoustic damping, and high fatigue endurance, are attractive to manufacturers. The weight savings combined with improved structural efficiency are directly translated into increased payload, reduced acquisition and operating costs, and increased performance. A pound of weight saved on a commercial aircraft is estimated to be worth $100 to $300 over the service life of the aircraft. *This has led to large sections of transport airframes, entire empennages and major portions of wing structure (see figure below), being made from composites.* The advantages of composites have been especially important to the helicopter and business aircraft; business aircraft have been built with all composite airframes, and helicopter rotor blades are fabricated entirely of composites or hybrid composite-metal combinations. The current fleet of small general aviation aircraft (GAA), however, have little or no composites. A NASA GAA initiative has been started to foster the use of composites in GAA. In the upcoming years, higher temperature capable polymeric composites, metal matrix, and ceramic matrix composite materials will find extensive use in engines and high-speed aircraft airframes such as the High Speed Civil Transport.



The goals of the research conducted at the William J. Hughes Technical Center are to ensure the safety of U.S. civil aircraft constructed of advanced materials and to advance U.S. aviation technology and expertise by encouraging use of advanced materials in airframes and engines.

The Advanced Materials Research program has been developed to meet the needs identified by the FAA, aircraft manufacturers, and airlines. It closely follows the current and forecasted advanced materials applications to airframes and engines. The future of general aviation aircraft is dependent on fabricating airframes out of composites that are affordable. Hence, materials research must also explore new methods of manufacture that are cost-effective. Although the use of composite materials has increased, there are still technical areas where lack of knowledge has resulted in composite structure that may be too conservatively designed and have poor supportability features. Filling the knowledge gaps will spur greater use of composites for applications such as transport aircraft wings and fuselages.

With each new technology innovation or evolution, the design variables (materials, concepts, and processes) to be assessed during the certification process will expand. The increased use by industry of verified structural optimization methodologies and analysis techniques to reduce cost of innovations will create pressure to streamline the qualification and certification time by reducing testing, but safety cannot be compromised. This is only possible with full understanding of material behavior and analytical modeling.

The advanced material research effort conducted at the Technical Center is being coordinated with other government agencies. Defense Advanced Research Projects Agency (DARPA) initiatives in defense conversion and dual-use technologies are leveraged for civil aviation needs. Also, active participation in the NASA-sponsored High Speed Civil Transport Research and General Aviation Programs offers additional opportunities. DOD and NASA, particularly the Advanced Composites Technology (ACT) program, are actively accelerating the development of a totally integrated technology base in advanced materials.

To find out more about the Advanced Materials Research Program, contact:

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